ESTIMATION OF CHUM SALMON ABUNDANCE AND SPAWNING DISTRIBUTION IN THE FISH RIVER COMPLEX, 2002

By

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OEO/ADA STATEMENT

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ABSTRACT

Todd, G. L. 2003. Estimation of Chum Salmon Abundance and Spawning Distribution in the Fish River Complex, 2002. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 3A04-28, Anchorage.

The Fish River system chum salmon radiotelemetry and sampling project assessed the feasibility of seining chum salmon in the lower Fish River for biological sampling (age-sex-length), monitored upriver movement of chum salmon using radio transmitter tags into tributary rivers and creeks, and estimated drainage abundance. Stationary radiotelemetry receiver sites placed below the tagging locations monitored tagged chum salmon that backed-out or left the drainage therefore were removed from the data, and to estimate possible mortality caused by handling and tagging. Receiver sites were placed above the tagging locations to estimate the proportions of chum salmon that entered Niukluk River drainage to spawn, or that continued up Fish River to spawn. Three aerial radiotelemetry surveys were conducted on tributary rivers and creeks to locate and estimate drainagewide distribution and document spawning areas.

Chum salmon were seined in the lower Fish River for biological sampling and 100 radio tags were deployed. Mark recapture methodology, using Niukluk River counting tower as recapture location was used to estimate total chum salmon abundance in the Fish River. A total of 87 tags were used in the estimate, 31 tags in Niukluk River. The 2002 chum salmon abundance was estimated at 93,357 ± 25,422. Predominant age class age-0.3 comprised 70.5% of the run; age class 0.4 comprised 25.1%. Sex ratio was 55.3% female and 44.7% male. Drainage distribution determined from aerial surveys was 35.6% Niukluk, 20.7% main stem Fish River, 14.9% Etehepuk River, 12.6% Boston Creek, and 16.1% in six other small tributaries.

Key Words: chum salmon, *Oncorhynchus keta*, Fish River, Niukluk River, Subdistrict 2 Norton Sound, Golovnin Bay, radiotelemetry, abundance, distribution, age-sex-length compositions

INTRODUCTION

Improved escapement enumeration is needed for Norton Sound harvest management through determination of key stocks of chum *Oncorhynchus keta*, coho *O. kisutch*, and pink *O. gorbuscha* salmon. Data are also needed to evaluate spawning activity, timing, distribution, and location. Coupled with characterization of age, sex, and length (ASL) composition, this information assists managers to set scientifically based escapement goals and improved stock specific harvest management and to address conservation issues. Norton Sound Salmon Management District includes all waters between the southern boundary at Point Romanof (near the village of Stebbins) and northern boundary at Cape Douglas, which is northwest of the Sinuk River mouth. The district is divided into six commercial salmon fishing subdistricts, three of which are in northern Norton Sound (Figure 1).

Norton Sound chum salmon returns have declined since the early 1980s. The Fish River drainage encompasses approximately 6,200 km^2 and is believed to be the second largest producer of chum salmon in the region after Unalakleet River. Chum salmon in this area are a major subsistence resource in the villages of White Mountain and Golovin, and contribute to small local commercial fisheries, although commercial fisheries have been restricted in the last decade in Golovnin Bay (subdistrict 2) because of continued weak returns and concerns for protecting chum salmon stocks (Figure 1). As subsistence fishing has been restricted around the Nome area, more people from Nome and summer residents of Council are now using this resource to help fill their subsistence needs, particularly around the road accessible area of the Niukluk River. ADF&G Subsistence Division monitored subsistence harvests at White Mountain (Georgette et. al. 2002) and Golovin, and Kawerak, Inc monitored harvests by people from the Nome area during 2000 and 2001.

Niukluk River is the largest Fish River tributary and is approximately 55 km long from its confluence with Fish River up to Libby Creek, the area where chum salmon are known to spawn. This tributary also supports subsistence fisheries, and is thought to provide spawning habitat for a significant portion of Fish River chum salmon, although currently how representative Niukluk chum salmon stock is of the Fish River stock is unknown. The amount of subsistence harvest above Niukluk tower and at road access point at Council is also unknown but thought to have increased during the last five years (Magdanz et. al. 2003); the Niukluk River total escapement remains unknown.

Niukluk River counting tower has operated yearly since 1995, and is used as an index count for chum salmon in the Fish River drainage for purposes of harvest management (Kohler and Todd 2003). Escapements and run timing to other portions of the Fish River drainage are monitored in season by airplane. Total drainagewide chum salmon escapement, age composition, and productivity are unknown. The assumption that the Niukluk is a major stock component in this drainage needs testing: it is unknown whether Niukluk shares similar stock characteristics: run and spawn timing, and age composition. Also unknown are areas used for spawning and what portion of suitable habitat is currently utilized. A goal for the Fish River system would be to understand the changes in productivity of its chum salmon population to contribute to analyses for sustainable subsistence, commercial and sport fisheries.

Primary objective of the 2002 Fish River chum salmon radiotelemetry project was to assess the feasibility of using radiotelemetry methodology to determine and improve estimation of chum salmon escapements in the Fish River drainage. Additional objectives were to gather age, sex, and length (ASL) data, determine migration timing and holding patterns, and locations and relative importance of major spawning areas. Specific project objectives for 2002 were:

1. Estimate the proportion of chum salmon fitted with radio tags in the lower Fish River that migrate upriver and pass the Niukluk River counting tower as representative of the total chum salmon population. Drainagewide escapement would be estimated as the ratio of the Niukluk tower count and the estimated proportion of total tagged.

2. Determine spawning location of chum salmon as represented by those chum salmon fitted with radio tags and tracked to their final spawning location within the Fish River drainage.

3. Estimate the age, sex, and length composition of chum salmon entering the Fish River drainage.

METHODS

This study employed radiotelemetry and mark-recapture methodology to estimate abundance, migration timing, drainagewide distribution, and major spawning areas. Radiotelemetry is a common method for fishery stock assessment (Todd et al. 2001, Wuttig and Evenson 2002), estimating fish abundance (Wuttig 1998, Hasbrouck et al. 2000, Evenson and Wuttig 2000) and for distribution and movement studies (Boyce and Eiler 2000, Meka et al. 2000). Aerial radio tracking and stationary receiver sites were used to monitor tagged fish passage and holding patterns and the counting tower was used for estimating escapement in the Niukluk River.

Radiotelemetry equipment

Advanced Telemetry Systems, Inc. (*ATS,* Isanti, MN) manufactured the radiotelemetry equipment used during this study. An *ATS* model R4000 receiver was interfaced by serial cable with an *ATS* model DCC II D5401 data collection computer at stationary receiver/data logging tracking sites. When interfaced, the DCC controls the receiver's operations, frequencies to scan, and draws power from the receiver. An internal backup battery is supplied in the DCC to prevent lost recorded data files if battery power is lost or becomes low. A 12-v marine battery and solar panel, wired through a solar charge controller, was used to power the receiver equipment at each site. Yagi 4-element antennae were used at all receiver sites and for aerial survey tracking. Antennae (at 6 m) and solar panel (3 m) were mounted to a 6 m high aluminum mast, which was bolted to the equipment box (receiver, DCC and battery were placed in a locking waterproof box). Antenna 1 monitored downriver and antenna 2 upriver direction of tagged fish, and at tributary confluence a third antenna covered the tributary. An antenna switchbox allowed scanning on all antennae simultaneously until a tag was received. The receiver would scan on each antenna for the amount of time programmed into the DCC setting: set to scan frequency for 5 s, with 2 s time out (if no frequency was found would go to next frequency). Before site deployment, all frequencies were entered manually into the DCC and scanning parameters set according to site-specific criteria. All cables were run inside the antenna mast to the equipment box to avoid possible damage from animals. Each time we accessed a site to download recorded data or test site coverage with a radio tag, battery voltages were checked using the DCC volt test feature.

ATS model F2110 pulse-coded radio transmitter tags (Eiler 1995) were attached externally to chum salmon (hereafter referred to as tags or tagged fish). Tags were equipped with a mortality switch, which activated when a fish remained motionless for approximately 4 h. They weigh approximately 15 g, and have an expected operational life in excess of 45 d. Ten frequencies in 149-150 MHz range with 10 pulse codes each, allowed detection of 100 unique identifiable tags. An *ATS* model R4100 receiver was used during aerial survey tracking flights, because this model receiver can de-code (identify, ID) pulse coded tags.

Stationary Receiver Sites

Sites were set up at three locations and tested with a radio tag before deployment of any radio tags (Figure 2). We selected sites based on river morphology, surrounding terrain, and acceptable receiver coverage. At each site water depth was measured perpendicular across the river along transects located at, above, and below each site, and down the middle of the river and along each bank. While conducting depth bathymetry transects, we suspended a radio tag 20-30 cm above the river bottom to approximate a tagged fish swimming along the river bottom to assess complete receiver coverage.

Site 1 was located 1 km downriver from the village of White Mountain, and was installed on a hillside approximately 15 m above the river (Figure 2). This site had two antennae and DCC was programmed to scan all frequencies, log, and store data continuously. Data were down loaded approximately weekly. Maximum water depths at Site 1 were 3.2 m across river transect, 4.0 m at above site transect, and 2.5 m below. This site was used to: 1) record tagged fish that moved downstream, or backed out, after release and were not available to upriver sites, 2) record tagged fish that moved downstream after initially moving upstream and that were recorded at upstream sites, and 3) record tagged fish that backed out but then returned upstream. Fish detected and recorded at Site 1 not identified as moving back upstream at a later date were censored from the data.

At Fish and Niukluk Rivers confluence we operated two sites to cover both Niukluk River channels (Figure 2). The upper Niukluk River channel, Site 2 was placed on the east river bank at the confluence, approximately 19 km upriver from tagging location, and had three antennae to monitor fish passage both up (antenna 2) and down river (antenna 1) in Fish River and up Niukluk River (antenna 3). Lower Niukluk channel, Site 3 was approximately 100 m up the secondary channel and approximately 18 km upriver from tagging location and had 2 antennae: antenna 1 for Fish River (no direction) and antenna 2 up channel. Both Niukluk sites were set to log continuously and store individual frequency and pulse data every 3 min initially. Later, this record was set to every 15 min. Data were downloaded approximately twice weekly. Water depths were shallow at both Niukluk confluence sites and maximum depths encountered during all bathymetry transects were 3-3.5 m in Fish River and 2.5 m in Niukluk River. Fox Creek enters Fish River down river from Niukluk River and therefore the two upper sites did not record tagged fish entering Fox River unless they migrated up river to Niukluk confluence before entering Fox Creek. Klokerblok River enters Fish River down river from Site 1 in the braided estuary.

Equipment problems encountered during the season did not allow collection of complete records from any site. Therefore, we used available data records to compute migration times and rates, so rates and times could be off somewhat. Migration rates and times were computed for Site 2 and Site 3 and also for Niukluk River spawning fish. Diel migratory timing was computed from the first record at each site for each recorded fish. Migration rates are the difference between time tagged and time of first record at a site. Entry into Niukluk River was computed from last record on antennae 3 at Site 2 and antennae 2 at Site 3.

Tagging and ASL Sampling

Salmon for ASL sampling and radio tagging were captured using a 45 m (150 ft length by 2 ¼ in mesh) beach seine. All seining was conducted in the lower Fish River in a 5 km stretch except for some of the last ASL pulse samples when fish were collected 15 km above the village of White Mountain. The lower end of the seining area was approximately 3 km above White Mountain (Figure 2). After both ends of the seine were pulled on shore, we anchored our boat in water less than 1 m deep. We then pulled the top of the offshore side of the seine over the side of the boat forming a "net pen" to hold fish while tagging and sampling. Chum salmon were netted and placed into a tagging/sampling cradle, modified from Larson (1995), a sliding meter stick was attached outside the cradle for length measurements, and side notches were deeper for scale collection and tagging. Fish remained under water during netting, placed in cradle and sampled or tagged except when the back of the cradle was lifted out of water to tag or collect scales. We released all fish at the seining locations without further holding. Tag deployment schedule was determined from historic chum salmon run timing in Kwiniuk and Niukluk rivers. In 2002, counts from more southern Norton Sound drainages were indicating chum salmon runs were early, and we may have been late starting so we deployed additional tags in the beginning.

Chum salmon were tagged and ASL samples collected from June 28 to July 18, 2002. Chum salmon other than those tagged were sampled for ASL composition; length is measured from mid-eye to tail fork (MEF) to within 0.5 cm, gender determined from visual observations, and scales collected from the primary growth area (Koo 1955) for age determination: three scale rows above the midline along a line from the trailing edge of the dorsal fin to the leading edge of the anal fin. Scales were cleansed of slime and placed on labeled gummed cards. The gummed cards were later pressed onto acetate cards with a scale press, and read with a microfiche scale reader for age determination (Tobias et al. 1994). We sampled three pulses of 160 fish during the run, representing the early, middle, and late portions of the migration. This sample size was selected so that simultaneous 95% confidence interval estimates of age composition proportions would be no wider than 0.20 (Bromaghin 1993), and to account for unusable scales sample size was increased an additional 8 to 9%. Each pulse sample was used to estimate the ASL composition of the run for a given temporal stratum. Standard methods were used to estimate ASL compositions and means.

Only healthy vibrant fish minimally impacted by capture were radio tagged, and to minimize handling stress we did not collect scales for ageing. Before tagging, tags were activated by removing the magnet and shaking, tagging needles were placed over the tag cables, and tags were dipped in a Betadine solution. We inserted needles through the flesh approximately 2 cm down on left side of body; the anterior needle was inserted between pterygiophore bones near the posterior edge of the dorsal fin, and second needle was inserted through musculature posterior of the dorsal fin (Barton 1992). Next, needles were removed and *Peterson* disk tags and sleeves were placed over the protruding cables. Tags were held firmly against the fish and sleeves were crimped tight on cable and excess cable cut (Winter et al. 1978). The anterior disk tag was sequentially numbered so if a fish was later caught or released, a record could exist. The Department posted a letter at several locations in White Mountain and Nome explaining the project and asking people to please release tagged fish, and record tag number, date, time, and location fish was harvested or released. We recorded time tagged along with length and sex information for each fish. Tags were released in sequence by pulse code and frequency. The lowest pulse code tags were all released in order by increasing frequency; the second pulse code tags were released in order by increasing frequency, etc. until all tags were used. A radio receiver and DCC were in the tagging boat (first 10 days) with a coaxial cable suspended overboard as an underwater antenna (McCleave et al. 1977, Solomon 1982). As fish were tagged and released the equipment recorded tag frequency and pulse code, and date and time automatically.

Aerial Surveys

During aerial telemetry surveys fish were recorded to within 1 km accuracy because of length of the main river and its tributaries, and time required to locate each fish to a more specific locale. Final destinations of tagged fish were assigned to upper most locations where the fish was found. Tags were not assigned a final destination if only located once on aerial surveys or if DCC data contradicted survey records. Two antennae were used during survey flights; each was mounted side looking with a 30 degree tilt down from horizontal on the aircraft wing lift strut (Gilmer et al. 1981, Kenward 1987). An aircraft switch box inside the fuselage (connected to both antennae) allowed the observer to switch between left, right, or both antennae to better locate the direction of tagged fish (Winter et al. 1978). When a tagged fish was pulse coded by the R4100 receiver, we recorded frequency and pulse code, mortality if activated, and river location on aerial survey log. Latitude and longitude of the tag were stored in a GPS (global position system) receiver by the aircraft pilot. On subsequent scan cycle, if tag signal strength was greater than previous cycle, new coordinates were stored. If the receiver was not able to identify the tag, the antenna switchbox was used to determine which antenna had the strongest reception; and if we had already passed the fish, the plane proceeded back until the tag was identified.

Aerial telemetry flights were conducted four times at altitudes of 150-300 m (500-1,000 ft) above ground level; 150 m in areas where numerous tagged fish were received at the same time, such as the confluence of Fish and Niukluk Rivers, and at 300 m in tributaries or areas where fish were widely dispersed. The first flight on 15 July covered Klokerblok River to mouth of Fish River, then up river to Fish River Flats with partial coverage of upper tributaries, and Niukluk River and Casadepaga tributary (*see* Figure 3). July 20 flight covered Niukluk River and tributaries, Fox Creek, and Fish River downriver from Niukluk River confluence. The 27 July flight partially covered rivers entering Norton Sound west of Golovnin Lagoon and rivers entering Golovnin Lagoon from the east to look for unaccounted tags and back outs, and covered the whole Fish River and all upriver tributaries except Star Creek. These flights were conducted using a *Piper* Super Cub PA-18. Only Niukluk River and Fox Creek were surveyed on August 7 using a Cessna 207, as the aircraft was only available for a short time. Lower Fish River surveys were a check of Site 1 to verify recorded data. Upper Fish River surveys were flown to determine tributary distribution and spawning timing, and to locate primary spawning areas. Niukluk River and tributary surveys were also conducted for above reasons, and to determine the number of tagged fish in the Niukluk River for estimating the drainagewide population.

Abundance Estimate

Carlson's method of Peterson's mark recapture (M-R), as modified by Chapman (1951), and reported in Seber (1982) was used to estimate the total Fish River chum salmon population. The Niukluk River counting tower expanded chum salmon count (a 20 min count each hour is multiplied by 3 to estimate hourly passage, *see* Kohler and Todd 2003) was expanded by the proportion of marked (radio tagged) chum salmon that migrated to and spawned in Niukluk River to estimate abundance.

$$\hat{N}=\frac{c(m+1)}{(r+1)}$$

where:

$\hat{N}$ = estimated chum salmon population in Fish River drainage,
c = recaptured chum salmon sample, not including marked fish,
m = marked and released chum salmon,
r = marked and recaptured chum salmon, and

variance of total abundance will be estimated using the following formula:

$$v(\hat{N})=\frac{(m+1)(c+r+1)c}{(r+1)^2(r+2)}$$

where:

$v(\hat{N})$ = variance of the estimate.

RESULTS

Tagging and ASL Sampling

Chum salmon tagging began on 28 June and finished on 18 July 2002 when all 100 tags were deployed (Table 1). Radio tag deployment tracked closely to the average chum salmon run timing from 1997-2002 at Kwiniuk River (Figure 4, top), although the start of tagging was slightly delayed from actual 2002 run timing. Tagging was approximately a week earlier than Niukluk River counting tower run timing at the beginning and finished approximately two weeks earlier (Figure 4, bottom).

Fish River chum salmon were sampled during three pulses for ASL composition over the course of the run for a combined total of 472 sampled. As expected, the percentage of males decreased in latter sampling periods and also for older age classes (ages 0.4 and 0.5), while female percentage increased by successive period (Table 2). Percent age class-0.3 increased by period (total, both sexes) while age class-0.4 percent was highest in the first sample period. Mean length by age class for males were greater the first period except during period 3 for age-0.5 (n=1). Female lengths generally decreased by age class and period. When all period samples were combined male mean lengths and age composition were: 59.2 cm and 67.4% age-0.3, 61.4 cm and 27.6% age-0.4, and 62.8 cm and 5.0% age-0.5 (Table 3). Female mean lengths and age composition were: 56.0 cm and 73.0% age-0.3, and 57.5 cm and 23.0% age-0.4. Males comprised 44.7% and females 55.3%, and age-0.3 comprised 70.5% and age-0.4 comprised 25.1% of the total 2002 samples.

In comparison, Niukluk River sex composition samples comprised more males, 53.6% and 46.4% female (Table 3), and predominant age class compositions were slightly different, 76.0% age-0.3 and 16.8% age 0.4. Sex ratio of radio tagged fish was equal, 50 percent male and female, and mean lengths for males was 61.5 cm and females was 57.6 cm (Table 4). ANOVA results of mean lengths by sampled group (Fish River radio tagged, Fish River ASL, and Niukluk River ASL) by sex were highly significant for both males and females ($P < 0.001$ males, and $P = 0.031$ females (Table 4). Fish River radio tagged chum salmon males showed a higher proportion in length range 62.5-65.5 cm and smaller proportion in the 55.5-58.5 cm range when lengths by sampled group and sex were compared (Figure 5, top). Proportion of radio tagged females was higher in length range 59-62 cm, approximately equal in female largest length range (62.5-65.5), and similar to radio tagged males, were fewer in the smaller length ranges (Figure 5, bottom).

Migration Rates and Timing

Approximately 50% of tagged fish migrated upriver shortly after release and were recorded at the upriver sites in less than 50 h (Table 5, Figure 6, top), and 8 and 12 fish recorded less than 20 h at Site 2 and Site 3, respectively. The calculated migration rate was 0.9 km/h, and the fastest fish migrated to Site 3 in under 12 h (1.5 km/h migration rate). Niukluk River spawning chum salmon recorded at Site 2 migrated upriver slightly slower than upper Fish River tagged fish, 50% within 60 h.

Diel migration timing by time periods tracked similar at both upriver sites and also when compared to Niukluk counting tower passage (Figure 6, bottom). Most of the recorded fish migrated at night from late evening (27.5% during 20-00 h) to early morning (23.2% during each period, 00-04 and 04-08 h), both sites combined (Table 6). Fish migration was lowest during midday to early afternoon, 12-16 and 16-20 h, 6.3% during each period (Table 6, Figure 6, bottom). Differences between sites were small except for Niukluk River spawning fish; 32.3% migrated between 04-08 h at both sites, and also during 20-00 h for Site 2 recorded fish.

Aerial Survey Distributions

Drainagewide distribution of tagged chum salmon was determined from the aerial survey flights. Of the 100 tags deployed, 96 were located during aerial surveys. Survey records contradicted DCC records for 5 tags, and one tag was recorded in two different locations (Table 7). Two tagged fish went downriver after tagging; one entered and presumably spawned in upper Klokerblok River, and the other fish entered Golovnin Lagoon after 19 days (DCC records) in Fish River and was subsequently subsistence harvested out of Golovin (Table 7). A total of 13 tagged fish were not assigned final destinations (6 Fish and 5 Niukluk), because they were: a) only located once by aerial surveys and not confirmed moving upriver by DCC records, b) DCC records contradicted aerial data, c) recorded at two different locations (1 tag), or d) lost, never recorded by DCCs or on any aerial survey (1 tag) (Table 7).

Destinations were assigned to 87 tagged fish: 31 in Niukluk River and 56 in Fish River, with 18 main stem and 37 in tributary drainages. Figure 3 shows the distribution of tagged fish in the Fish River drainage that were located during survey flights conducted on 15, 20 and 27 July 2002 including some tags not assigned destinations. Tagged fish distribution in Niukluk River drainage, from the three survey flights is shown on Figure 7. Four tags were recorded in Casadepaga Creek although 2 were only located once. Figure 8 shows tagged fish distribution in upper Fish River above confluence with Niukluk River from the three surveys. Drainage distribution was 35.6% Niukluk, 20.7% main stem Fish River, 14.9% Etehepuk River, 12.6% Boston Creek, and 16.1% (14 tags) in six other smaller tributaries.

Abundance Estimate

I used Carlson's method to estimate the 2002 chum salmon escapement in the Fish River drainage. I made two estimates; one estimate includes only tags with assigned destinations (87), and the second used all tags in the Fish River including tags located only once (98). Tags were not assigned a final destination if only located once on aerial surveys or if DCC data contradicted survey records. Recapture sample number from 2002 expanded Niukluk River tower chum salmon counts was 33,979, and the number of marked fish that were recaptured in Niukluk River was 31 assigned and 36 total (*see* Table 7). Assigned tag estimate is 93,357 with a 95% confidence interval (CI) of ± 25,422, and variance of 168,226,458. Total (all tags, 98) estimate was 90,820 with 95% CI of ± 22,865, and variance of 136,085,997.

DISCUSSION

Norton Sound harvest management can benefit from improvements to existing programs for the collection of catch and escapement data (NSSRR STC 2002). If a consistent proportion of the Fish River population spawns in the Niukluk River, expansion of past and future data to estimate total Fish River escapement and harvest rates in subsistence and commercial fisheries would be possible. Testing of this hypothesis will need additional years of data. Fish River chum salmon total production, spawning escapement and harvest, and chum salmon age composition would need to be known for enough years to develop brood year tables and escapement goals. Accompanying ASL data would allow us to estimate return-per-spawner and quantify spawner success, and additional study years should allow us to determine the proportion of chum salmon migrating to all major tributaries of the Fish River system, and determine main spawning areas and timing. Understanding spawning ground usage, spawning success and freshwater survival are important to understanding productivity and this project could ultimately provide the sampling platform for additional investigations. In the future, we may use knowledge of habitat availability and usage for escapement goal development. Also, Northwest Alaska summer chum salmon have high genetic similarity, therefore sampling has not been able to define or determine sub-stocks to drainages (Seeb and Crane 1999), which precludes offshore marine studies for stock separation and abundance estimators. Initial study proposed only tagging 25 fish and Norton Sound Salmon Research and Restoration Steering Committee approved 100 radio tags to be more cost effective during this first year pilot study.

Technical problems were encountered with the *ATS* DCC during the season, therefore monitoring of fish movement and passage at all receiver sites is incomplete. Initially we were unable to down load recorded data from the DCCs to a laptop computer and before the problem was corrected memory capacity was reached at the two upriver sites and recording stopped. In addition, an internal chip problem in the DCCs may have contributed to incomplete recording of data, which was not corrected until new chips were received and installed on 18 July. Site 1 contained records of fish migrating down river but not back upriver, and some of those fish were located upriver at later dates during aerial surveys.

Fish River below White Mountain is approximately 10 km long and braids into several channels before draining into Golovnin Lagoon. We attempted gillnetting in the lower braided estuary section without success in an attempt to assess spawning in these lower tributaries, most of which are very small and may not have suitable spawning habitat. Although one tagged fish backed out below the lower receiver site and then migrated up Klokerblok Creek, the largest lower tributary, we presumed it spawned.

The difference between the two abundance estimates (87 assigned tags and 98 total) was less than 3,000 fish, or approximately 3 percent. This small difference in the estimates when using different numbers of tags suggests if a few tags were not correctly identified or locations were incorrect, the estimate would still be valid and would not change significantly. Differences in mean lengths between sampled groups were small and although statistically significant may not be biologically significant, and the data does not determine any bias in sampling or tagging. Although radio telemetry data is useful for migratory behavior, stock separation and location of spawning areas, it is more qualitative than quantitative (Milligan et. al. 1986).

External tag placement was easily accomplished and it took approximately 2 to 2 ½ minutes to take a fish from a dip net and place in cradle, tag and release, and record data. Wuttig and Evenson (2002) found no differences in coho salmon tagged with external or internal (esophageal or implanted) radio tags by proportion tagged that resumed migration upriver or average time to recover and resume migration after tagging, while Brown and Eiler (2000) found internal tagged female inconnu *Stenodus leucichthys* traveled greater distances, delayed less after tagging, and greater proportion resumed upriver migration than external tagged fish. Of 100 tags deployed only one remained in the vicinity of seining and tagging location and may have dropped off; while other studies using internal tags report of regurgitated tags (Evenson and Wuttig 2000, Wuttig and Evenson 2002). Because we only had two upriver receivers (both similar distance, 18 km), we could not accurately determine daily migration rates, and calculated rate per hour based on time tagged to time recorded at receiver at 0.9 km/h, and if expanded to 24 h would be 22 km/d. Cappiello and Bromaghin (1997) calculated migration rates for spaghetti tagged chum salmon captured in fish wheels at 26 km/d.

CONCLUSION

Results from this first year pilot study were successful: a) fish were easily seined, b) sampling and tagging goals were met, c) external tag placement did not seem to adversely affect fish behavior or migration, d) tagging and sampling schedules tracked well with other close chum salmon monitoring projects, and e) distribution throughout the drainage was documented from the aerial tracking surveys. Project objectives were also achieved: a) the proportion of tagged chum salmon that migrated up the Niukluk River was determined from stationary receiver site records and aerial telemetry flights, and expanded to estimate drainage-wide escapement, b) spawning locations (some new and for some contribution to total increased) were documented in most tributaries from aerial telemetry flights, and c) age, sex, and length compositions were documented for main Fish River and compared to Niukluk River.

Recommendations for continuing studies:

1. Continue with the project following the same general study plan as 2002, although begin tagging earlier if fish are netted in sufficient numbers, and collect ASL information on all fish tagged.

2. Increase the number of radio tags to 160 for 95% CI for multinomial distribution, as recommended by ADF&G, Division of Commercial Fisheries. biometrician,

3. Increase number of aerial surveys and conduct first survey earlier for more complete coverage of initial movement, to determine final spawning locations and to estimate spawning timing.

4. If additional funding is available, increase number of receiver sites for more complete coverage of major upper tributaries to monitor holding and movement patterns before fish enter spawning tributaries. Few fish migrated in the secondary Niukluk River confluence channel, move this site to the counting tower to estimate abundance on counts and recapture above the tower.

5. Conduct tracking surveys by boat when boats travel upriver or downriver to check and download sites.

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Table 1. Radio tag deployment on chum salmon in the Fish River, by date and sex, 2002.

Date	Number	Cumulative	Male	Female
28-Jun	13	13	4	9
30-Jun	6	19	3	3
2-Jul	11	30	6	5
5-Jul	12	42	4	8
6-Jul	16	58	8	8
9-Jul	12	70	8	4
11-Jul	10	80	6	4
13-Jul	10	90	5	5
16-Jul	5	95	4	1
18-Jul	5	100	2	3
Total	100		50	50

Table 2. Age and sex compositions, and mean length (mid-eye to tail fork, MEF cm) and ranges by age class and period (pulse) for Fish River ASL sampled chum salmon, 2002.

		Brood Year and (Age Class)				
		2000 (0.2)	1999 (0.3)	1998 (0.4)	1997 (0.5)	Total [a]
Period dates:	6/27 - 7/4					
Sampling dates:	6/28 - 7/2		Pulse 1			
Male	Percent		57.6%	30.3%	12.1%	47.5%
	Number	0	38	20	8	66
	Mean MEF (cm)		60.3	63.0	62.8	
	S.D. length		1.961	3.681	3.173	
	Length range (cm)		56.0 - 66.0	56.5 - 68.0	60.0 - 67.5	
Female	Percent	1.4%	69.0%	22.5%	7.0%	52.5%
	Number	1	49	16	5	71
	Mean MEF (cm)	56.5	57.1	57.7	59.4	
	S.D. length		2.586	2.971	6.279	
	Length range (cm)		51.5 - 63.5	52.5 - 61.0	51.0 - 65.5	
Total	Percent	0.7%	63.5%	26.3%	9.5%	
	Number	1	87	36	13	137
	Mean MEF (cm)	56.5	58.5	60.6	61.5	
	S.D. length		2.826	4.288	4.690	
	Length range (cm)		51.5 - 66.0	52.5 - 68.0	51.0 - 67.5	
Period dates:	7/5 - 12					
Sampling dates:	7/7 - 9		Pulse 2			
Male	Percent		72.1%	27.9%		45.6%
	Number	0	44	17	0	61
	Mean MEF (cm)		59.2	59.7		
	S.D. length		2.662	3.825		
	Length range (cm)		53.0 - 64.0	52.0 - 67.5		
Female	Percent		69.2%	29.5%	1.3%	54.4%
	Number	0	54	23	1	78
	Mean MEF (cm)		55.7	57.2	58.5	
	S.D. length		2.317	2.606		
	Length range (cm)		49.5 - 61.5	52.0 - 62.5		
Total	Percent		70.5%	28.8%	0.7%	
	Number	0	98	40	1	139
	Mean MEF (cm)		57.2	58.3	58.5	
	S.D. length		3.033	3.384	5.009	
	Length range (cm)		49.5 - 64.0	52.0 - 67.5		
Period dates:	7/13 - 20					
Sampling dates:	7/13 - 18		Pulse 3			
Male	Percent		74.1%	24.1%	1.9%	40.8%
	Number	0	40	13	1	54
	Mean MEF (cm)		58.3	61.3	63.0	
	S.D. length		2.521	4.166		
	Length range (cm)		54.5 - 66.5	54.5 - 69.0		
Female	Percent	1.4%	80.8%	16.4%	1.4%	59.2%
	Number	1	59	12	1	73
	Mean MEF (cm)	48.5	55.4	58.0	55.5	
	S.D. length		2.566	2.500		
	Length range (cm)		48.5 - 61.5	54.0 - 63.0		
Total	Percent	0.8%	78.0%	19.7%	1.6%	
	Number	1	99	25	2	127
	Mean MEF (cm)	48.5	56.6	59.7	59.3	
	S.D. length		2.899	3.775		
	Length range (cm)		48.5 - 66.5	54.0 - 69.0		

[a] Percent sex composition includes fish that were not aged or lengths measured, total does not include these counts.

Table 3. Age and sex compositions, and mean length (mid-eye to tail fork, MEF cm) and ranges by age class, for Fish and Niukluk Rivers ASL sampled chum salmon, 2002.

		Brood Year and (Age Class)				
		2000 (0.2)	1999 (0.3)	1998 (0.4)	1997 (0.5)	Total [a]
Sampling dates:	6/28 - 7/18		Fish River			
Male	Percent		67.4%	27.6%	5.0%	44.7%
	Number	0	122	50	9	181
	Mean length		59.2	61.4	62.8	
	S.D. length		2.528	4.036	2.969	
	Length range (cm)		53.0-65.5	52.0-69.0	59.0-67.5	
Female	Percent	0.9%	73.0%	23.0%	3.2%	55.3%
	Number	2	162	51	7	222
	Mean length	52.5	56.0	57.5	58.7	
	S.D. length		2.575	2.670	5.330	
	Length range (cm)		48.5-63.5	52.0-63.0	51.0-65.5	
Total	Percent	0.5%	70.5%	25.1%	4.0%	
	Number	2	284	101	16	403
	Mean length	52.5	57.4	59.5	61.0	
	S.D. length		3.013	3.923	4.529	
	Length range (cm)		48.5-66.5	52.0-69.0	51.0-67.5	
Sampling dates:	7/7 - 7/26		Niukluk River [b]			
Male	Percent		74.9%	16.9%	8.2%	53.6%
	Number	0	182	41	20	243
	Mean length		58.7	60.8	62.1	
	S.D. length		3.055	2.960	3.347	
	Length range (cm)		46.5-68.5	50.9-65.5	55.4-68.2	
Female	Percent	0.5%	77.3%	16.7%	5.4%	46.4%
	Number	1	157	34	11	203
	Mean length	55.7	56.1	57.7	58.5	
	S.D. length		2.497	2.430	3.376	
	Length range (cm)		50.0-65.0	52.0-63.0	55.0-65.0	
Total	Percent	0.2%	76.0%	16.8%	7.0%	
	Number	1	339	75	31	446
	Mean length	55.7	57.5	59.4	60.8	
	S.D. length		3.088	3.142	3.751	
	Length range (cm)		46.5-68.5	50.9-65.5	55.4-68.2	

[a] Total percent sex composition includes fish that were not aged or measured, total number does not include these counts.
[b] Niukluk River mean lengths were measured to nearest mm (MEF).

Table 4. Results of ANOVA to test for differences in chum salmon mean lengths (MEF, cm) by sample group, by sex (males top, females bottom) in the Fish River drainage, 2002. *P* -values less than 0.05 are significant.

SUMMARY MALES

Groups	*Count*	*Sum*	*Average*	*Variance*	*SE*
Fish River radio	50	3,073	61.45	9.707	0.441
Fish River ASL	211	12,682	60.10	10.308	0.221
Niukluk River ASL	261	15,488	59.34	10.606	0.202

ANOVA

Source of Variation	*Sum-of-Squares*	*df*	*Mean-Square*	*F -ratio*	*P-value*	*F crit*
Between Groups	209.5	2	104.73	10.070	**<0.001**	3.013
Within Groups	5,398.0	519	10.40			
Total	5,607.5	521				

SUMMARY FEMALES

Groups	*Count*	*Sum*	*Average*	*Variance*	*SE*
Fish River radio	50	2,879	57.58	7.330	0.383
Fish River ASL	261	14,749	56.51	7.735	0.172
Niukluk River ASL	226	12,778	56.54	6.765	0.173

ANOVA

Source of Variation	*Sum-of-Squares*	*df*	*Mean-Square*	*F-ratio*	*P-value*	*F crit*
Between Groups	50.8	2	25.41	3.487	**0.031**	3.013
Within Groups	3,892.2	534	7.29			
Total	3,943.1	536				

Table 5. Radiotagged chum salmon migration times from tagging locations to stationary receiver sites, time tagged to first DCC record by site (hours), Fish River drainage, 2002.

	First record, all tagged fish			First record for tagged fish migrating into Niukluk River	
Parameter	LNS	UNS[1/]	LFS	LNS	UNS
N	81	60	15	27	21
Mean	49.8	67.1	230.2	50.7	81.1
Median	40.7	49.2	250.0	40.3	57.4
Minimum	11.8	12.4	4.4	14.6	16.5
Maximum	203.1	228.2	488.6	197.1	224.9
N <Median	40	30		13	10
Mean	28.1	29.9		29.5	36.9

[1/] UNS values includes fish less than 240 hours (10 days), one fish was deleted (687 hours).

Table 6. Radiotagged chum salmon diel migration timing at stationary receiver sites, number and percent from first DCC records, Fish River drainage, 2002.

	Migration period (hour)												
Site	00-04		04-08		08-12		12-16		16-20		20-00		*N*
	First record, all tagged fish												
LFS[1/]	3	20.0%	2	13.3%	4	26.7%	1	6.7%	4	26.7%	1	6.7%	15
LNS	19	23.5%	20	24.7%	11	13.6%	6	7.4%	7	8.6%	18	22.2%	81
UNS	14	23.0%	13	21.3%	8	13.1%	3	4.9%	2	3.3%	21	34.4%	61
LNS & UNS	33	23.2%	33	23.2%	19	13.4%	9	6.3%	9	6.3%	39	27.5%	142
	First record for tagged fish migrating into Niukluk River												
LNS-N	6	22.2%	9	33.3%	5	18.5%	1	3.7%	2	7.4%	4	14.8%	27
UNS-N	3	14.3%	7	33.3%	1	4.8%	2	9.5%	1	4.8%	7	33.3%	21

[1/] LFS monitored tagged fish movement down river from tagging locations, and was used to censor tags that did not return upriver. Reported diel timing may not be representative of normal fish movement, but fish stressed from handling or other factors.

Table 7. Fish River radiotelemetry chum salmon distribution by drainage, from aerial radiotracking and DCC records by assigned final destination and not assigned (only 1 locate or conflicting data), 2002.

		Assigned		Not Assigned
River	Tributary	Number	Percent	
Fish	main stem	18 [a]	32.1% [b]	4 [c, d]
	Boston	13 [e]	23.2% [b]	
	Cache	1	1.8% [b]	
	Etehephuk	11	19.6% [b]	1 [c]
	Fox	4	7.1% [b]	1 [c]
	Paragon	4	7.1% [b]	
	Rathlatulik	1	1.8% [b]	
	Telephone	3	5.4% [b]	
	Total tributaries	37		
	Klokerblok	1 [f]	1.8% [b]	
Total Fish R. and tribs.		56	64.4% [g]	6
Niukluk		29		3 [c, d]
	Casadepaga	2		2 [c]
	Total	31	35.6% [g]	5
			Missing	1 [h]
			Conflict	1 [i]
	TOTAL	87		13

[a] Two fish were subsistence harvested; one was in Fish River for 19d before harvest in Golovnin Bay.

[b] Percent from Fish River and tributaries total, and does not include Niukluk River.

[c] Only one aerial locate and not confirmed upriver by DCC records.

[d] No aerial locate and or DCC records inconclusve.

[e] One fish was in Baker Creek, a tributary of Boston Creek..

[f] Klokerblok enters Fish River below White Mountain.

[g] Percent of all assigned total.

[h] Lost tag, no aerial locate or DCC record.

[i] Located in Pargon and Niukluk on different aerial surveys.

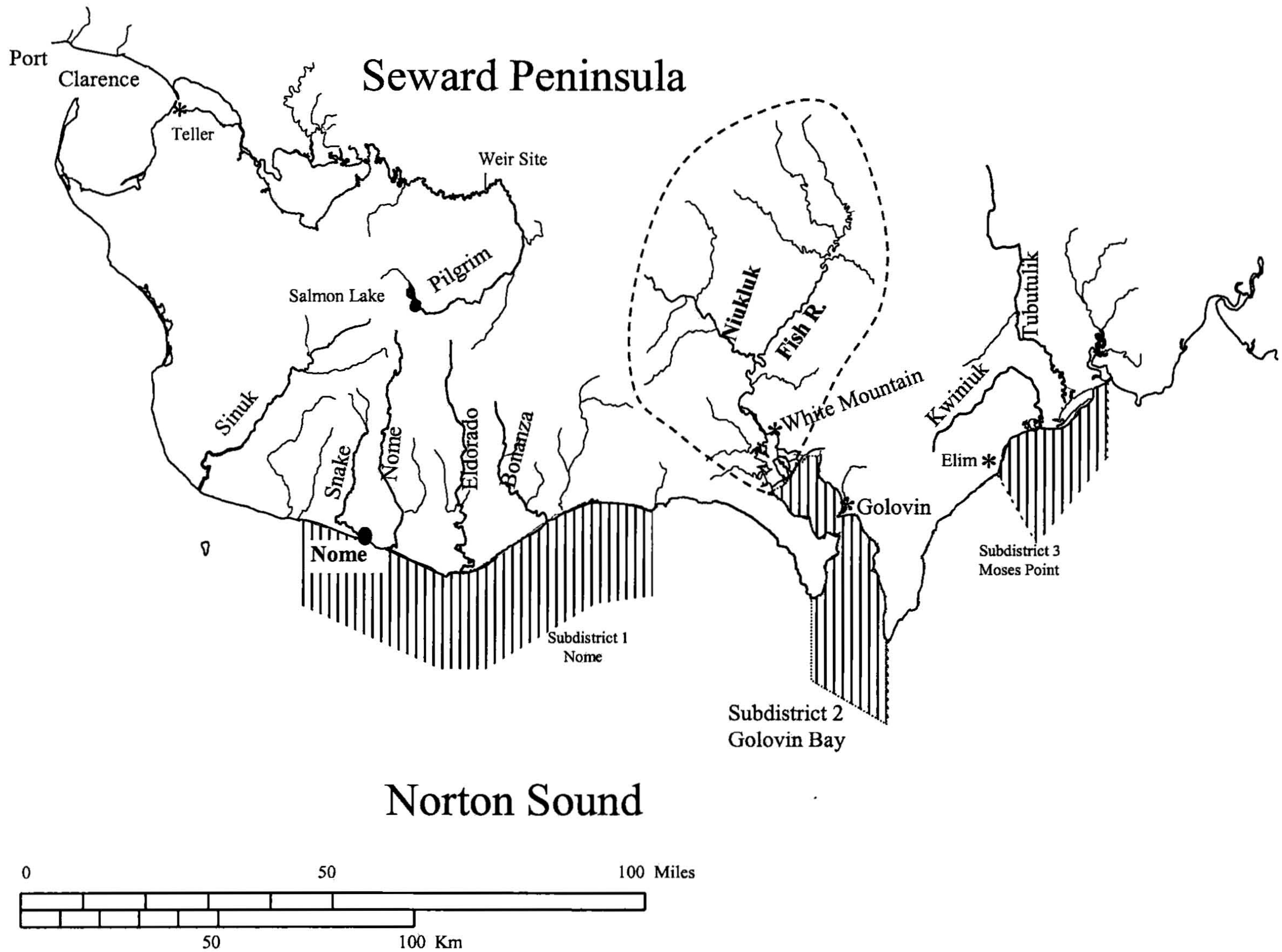

Figure 1. Southern Seward Peninsula Area map showing northern Norton Sound commercial fishery management subdistricts and Golovnin Bay (subdistrict 2), White Mountain village, and Fish River drainage (project area, inside dashed line).

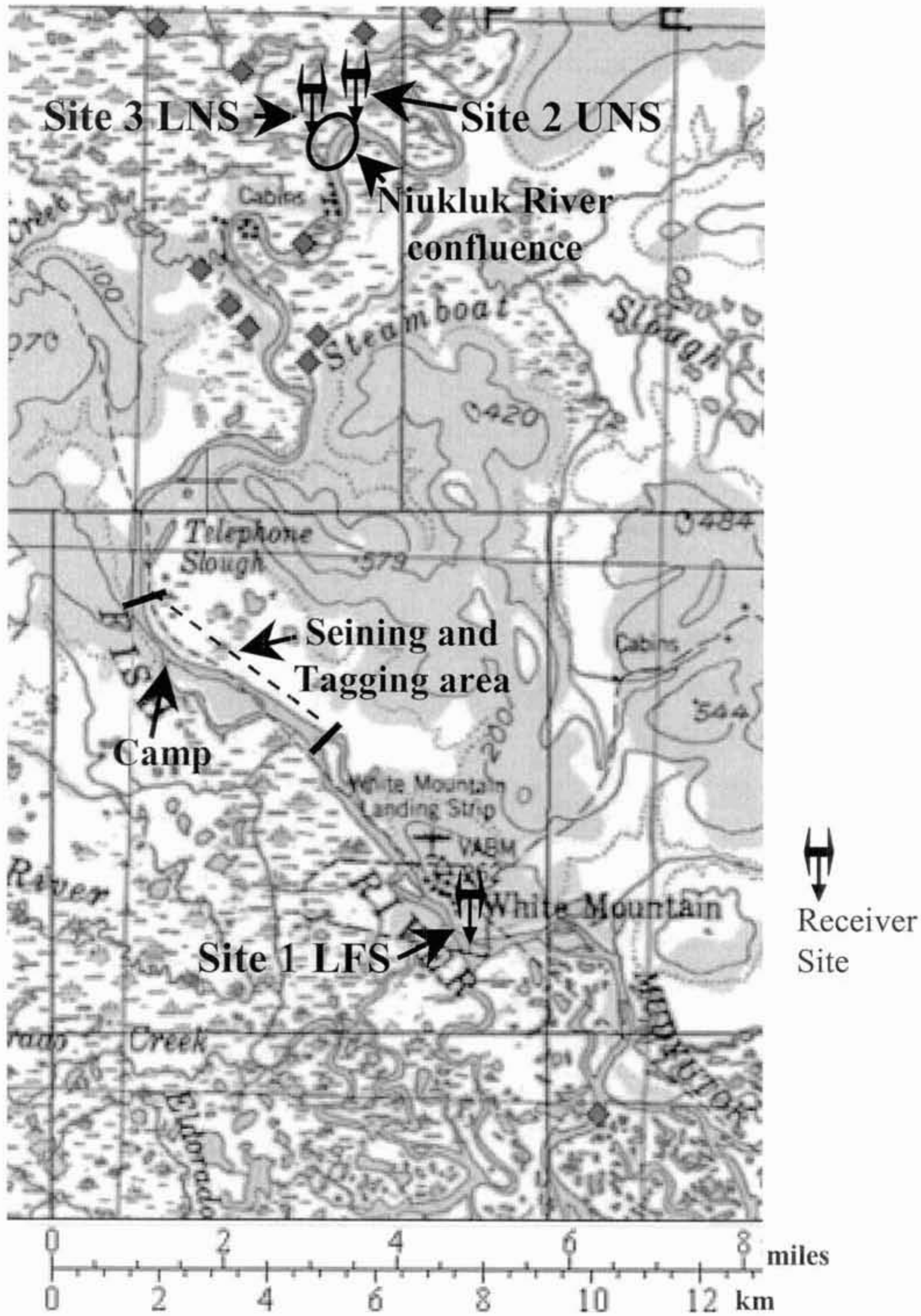

Figure 2. Map of lower Fish River showing locations of seining and tagging area, stationary receiver sites, and Niukluk River confluence, 2002.

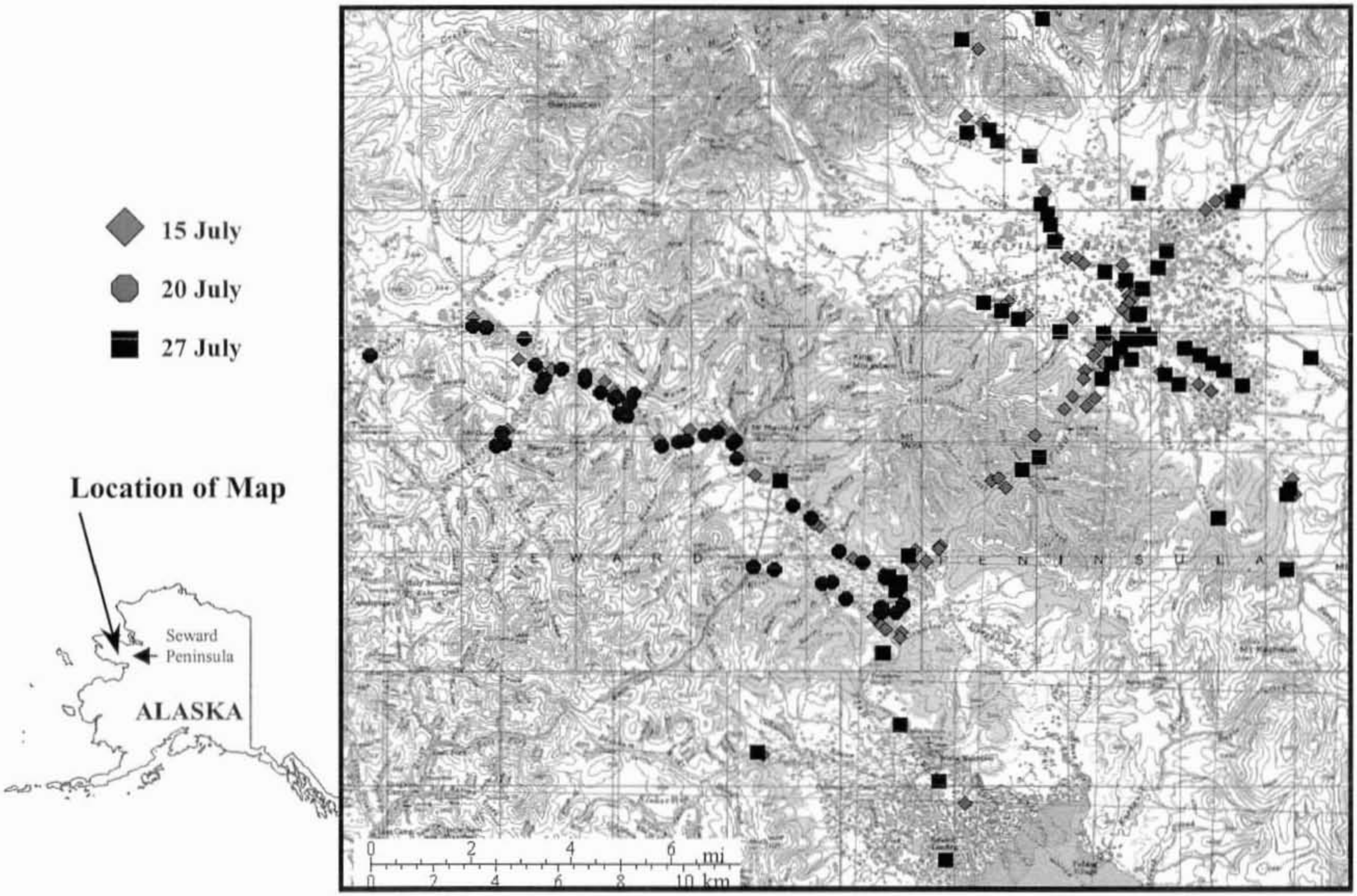

Figure 3. Map of Fish River drainage showing locations of all radiotagged chum salmon from aerial survey tracking flights, 2002.

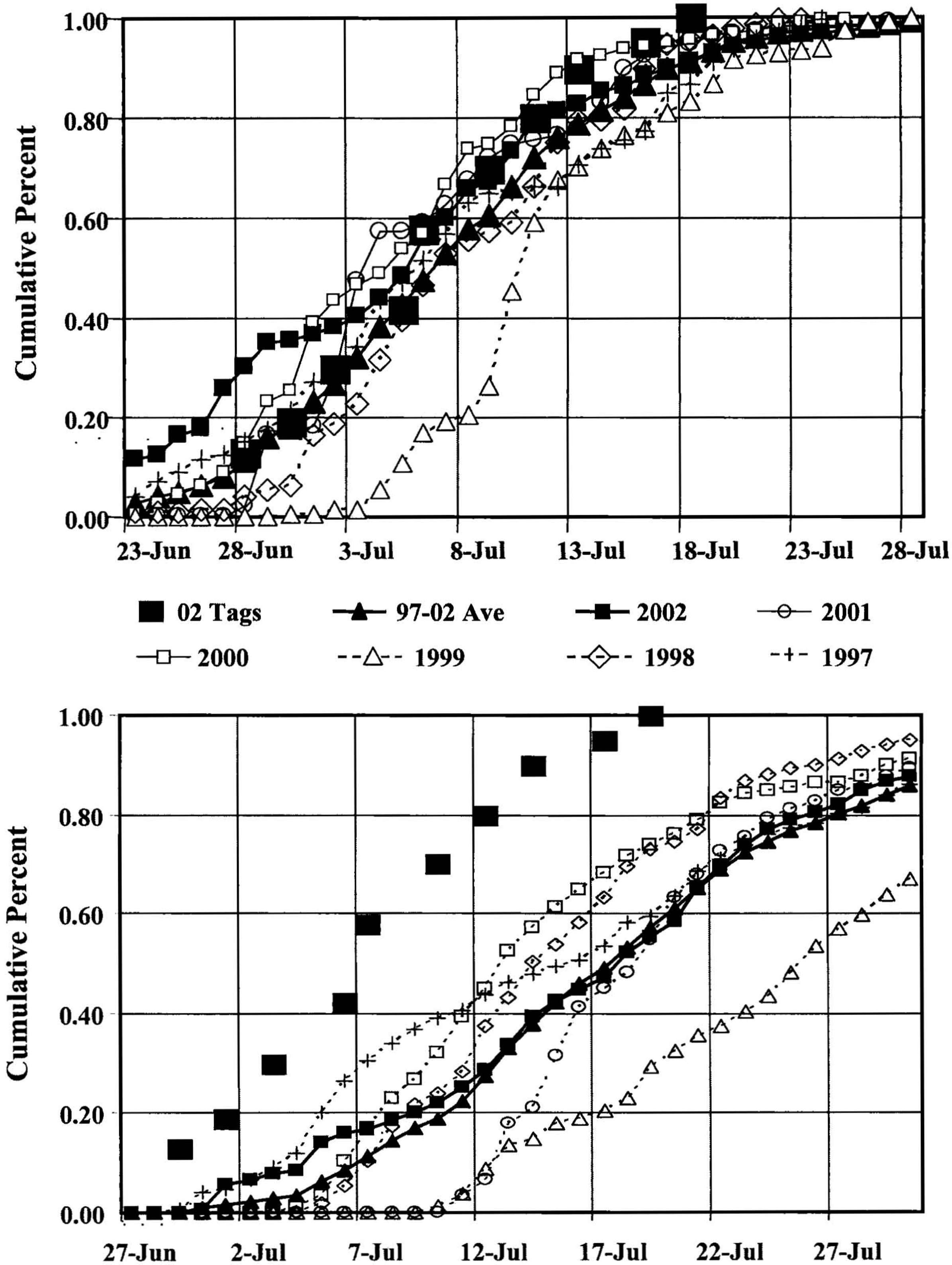

Figure 4. Comparison of chum salmon run timing (1997-2002) and averages at Kwiniuk (top) and Niukluk (bottom) counting towers to radio tag deployment during 2002.

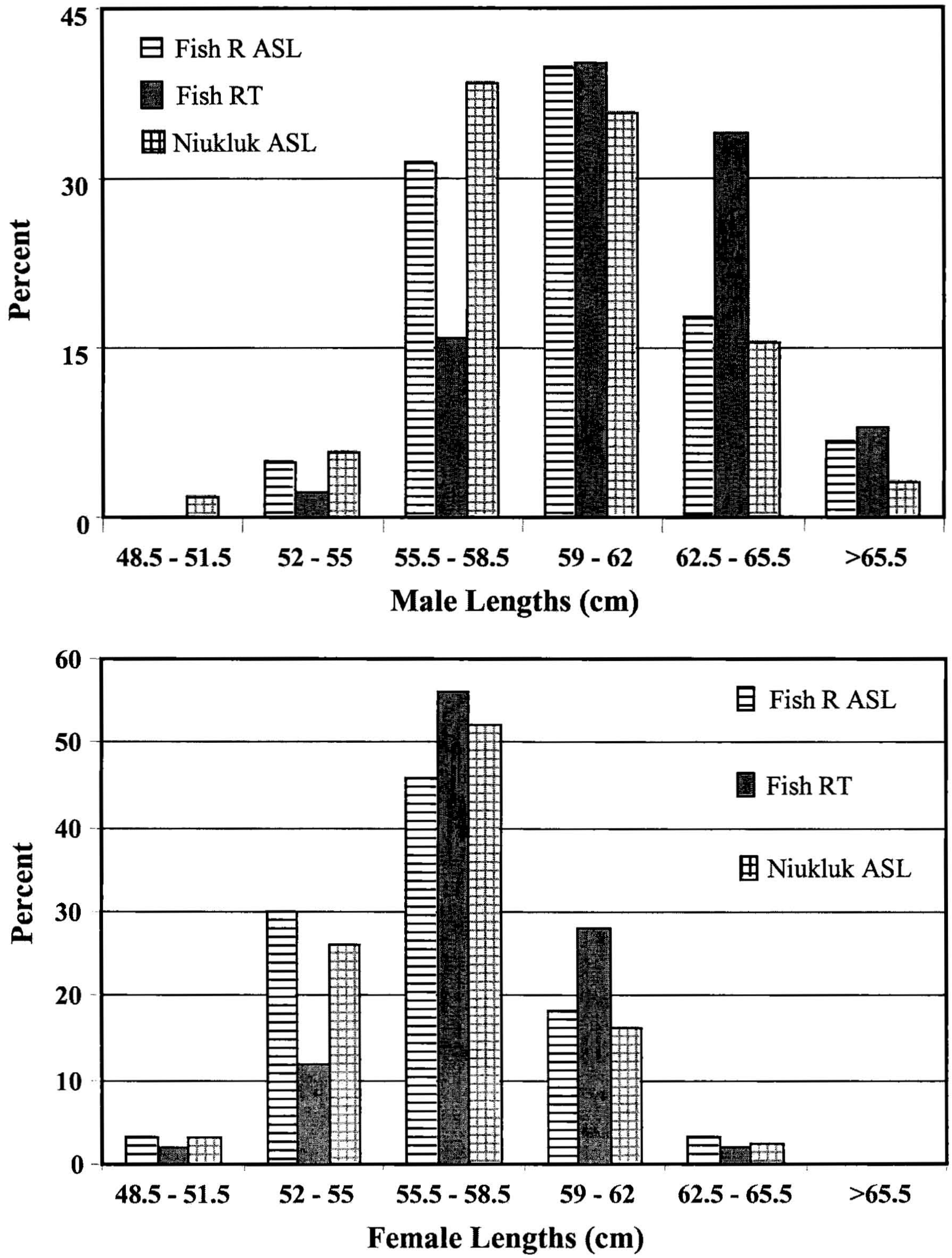

Figure 5. Percent length frequency distribution (mid-eye to tail fork, cm) by sampled group and sex, males (top) and females (bottom), Fish River (Fish R ASL), Fish River radiotagged (Fish RT), and Niukluk River (Niukluk ASL), 2002.

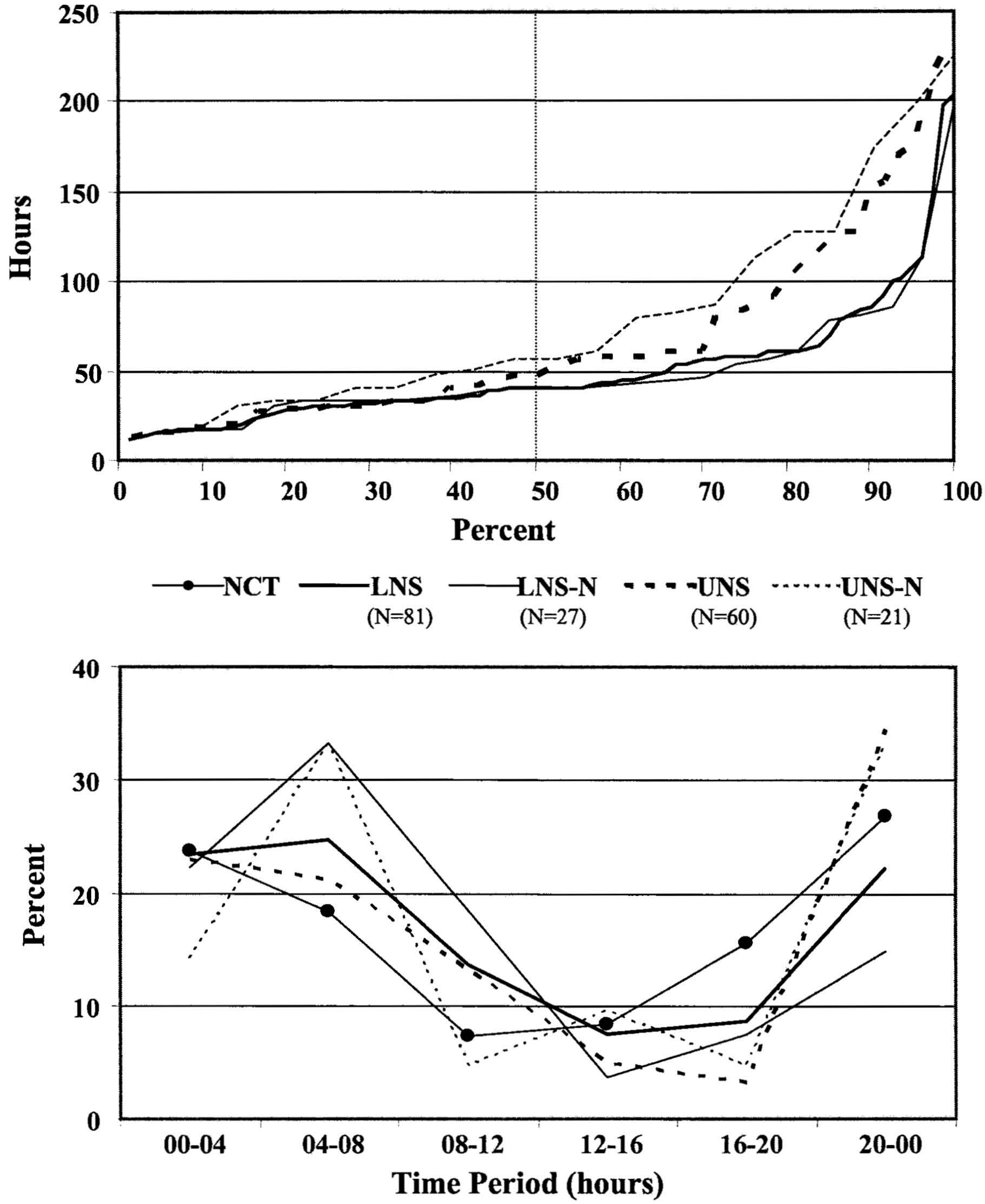

Figure 6. Radiotagged chum salmon migratory timing from first records at stationary receiver sites for all recorded fish and Niukluk River spawning fish (LNS-N and UNS-N); hours from tagging to record at sites for fish less than 240 hours (top), and diel migratory timing and chum salmon passage at Niukluk River counting tower (NCT) (bottom).

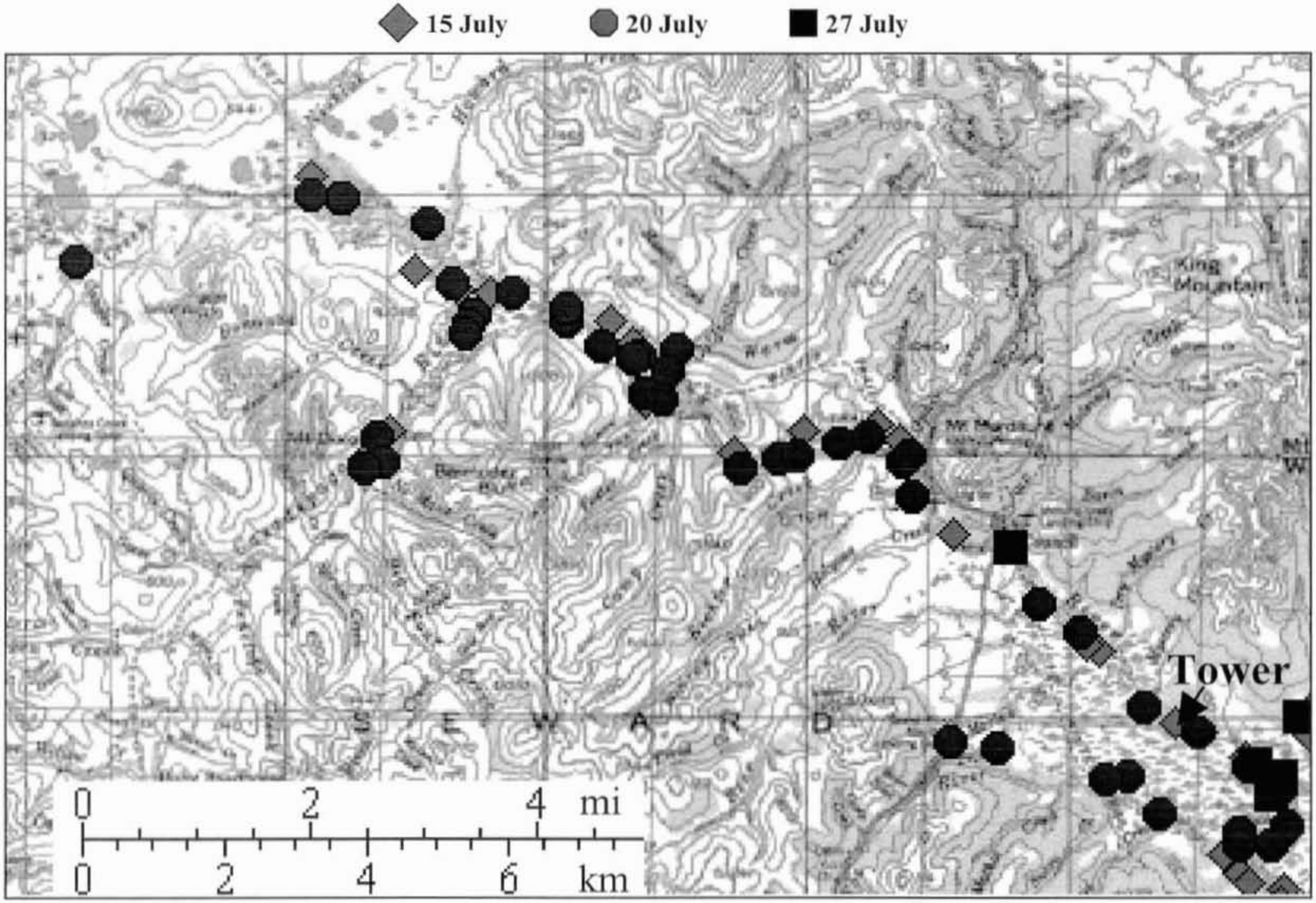

Figure 7. Location of Niukluk River salmon counting tower, and distribution of radiotagged chum salmon in Niukluk and Fox River drainages from aerial survey tracking flights, 2002.

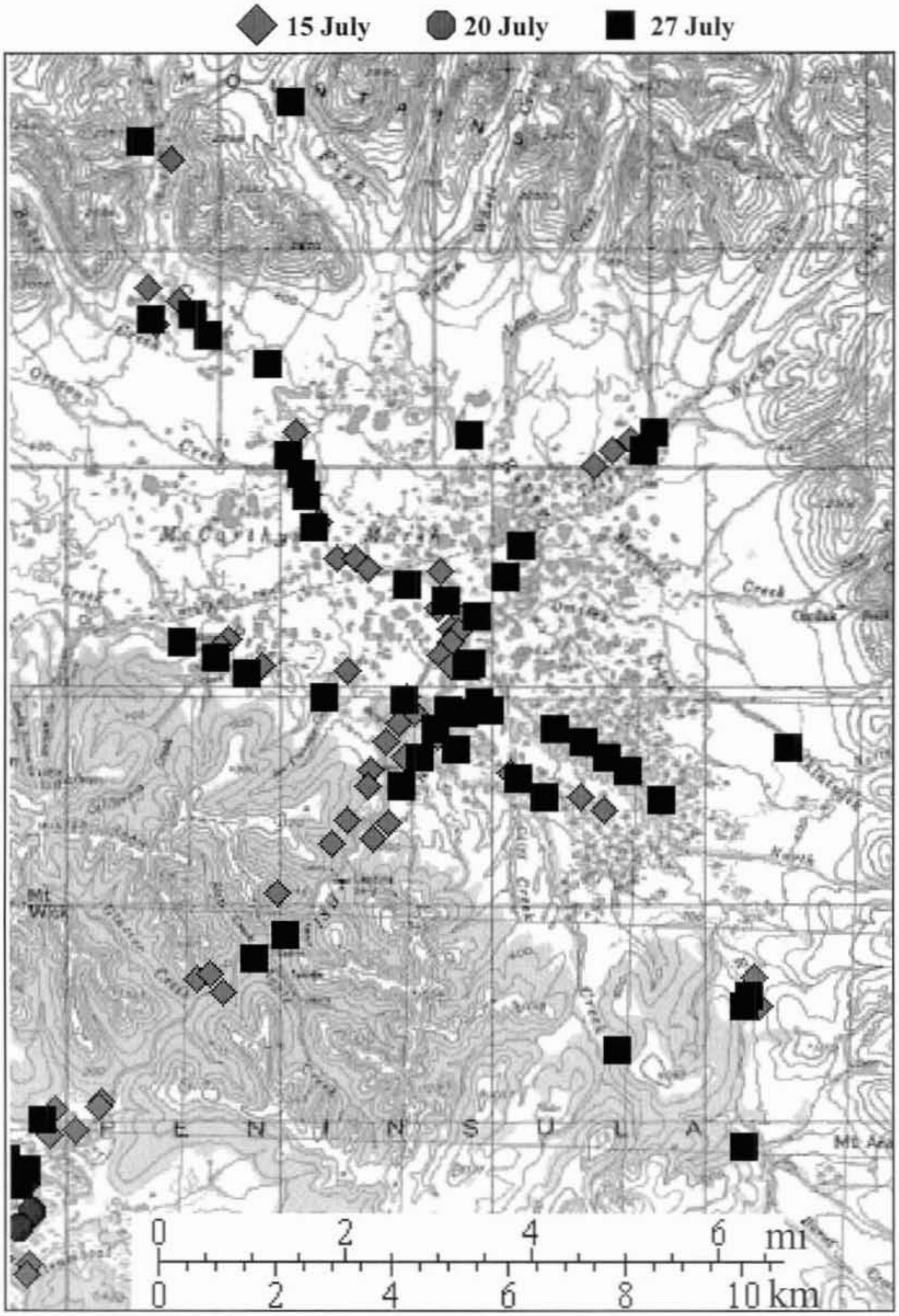

Figure 8. Distribution of radiotagged chum salmon in the upper Fish River drainage from aerial survey tracking flights, 2002.